HARVESTING TECHNOLOGY WATCH

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Summary

TECHNOLOGY WATCH is a biannual report outlining research and technology developments that are occurring outside the FFR Harvesting Theme, frequently from overseas. This report covers the following subjects: in New Logging Technology the focus is on systems for slash removal from waterways; Overseas Harvesting Research looks at fully mechanised thinning and carbon emissions from timber harvesting; and in Technology Outside Forestry an innovative remote controlled prototype vehicle called the Omni-Crawler is investigated

Author: Dzhamal Amishev, Scion

NEW LOGGING TECHNOLOGY

Slash Removal from Streams

In order to satisfy resource consent conditions, most harvesting operations are required to remove slash and woody debris from gullies with continuously running water. Many forest companies are removing slash even from drier gullies that have a potential to mobilise large amounts of woody debris in major storm events. Some methods to cope with debris flows include a specifically designed grapple for slash removal, using a low-cost mini-yarder, "walking" mini-excavators, or (most commonly), using manual labour.

The Heli-Claw

The USDA Forest Service Missoula Technology and Development Centre designed and fabricated a large, lightweight grapple for use by a helicopter or small cable yarder, dubbing the new device the "Heli-claw" (Figure 1).When the Heli-claw is suspended on a 30-metre longline beneath a helicopter, the helicopter pilot can independently pick up, transport, and drop up to one tonne of woody material or straw or similar material.

The Heli-claw comprises a set of 3-metre steel "jaws" which compress the load so it can be lifted and transported. The Heli-claw's jaws can be adjusted anywhere between fully open (jaws three metres apart) and fully closed. The teeth along each jaw are made from hardened ¼-inch steel plate. Each tooth is attached to the jaw with just two bolts, allowing a damaged tooth to be replaced in a few minutes.

After the pilot lowers the open Heli-claw on a pile of mulch (or other materials), it takes less than 10 seconds to close the jaws and begin lifting the load.

Figure 1. The Heli-claw open in flight.

A central steel frame provides an attachment point for the helicopter's longline and serves as a hinge point for the jaws.

The Heli-claw is hydraulically powered and the hydraulics are driven by a 6.5 HP Honda petrol motor. The steel frame also serves as a reservoir for hydraulic fluid and as a cooling system.

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A removable Lexan plastic vertical stabiliser/rudder prevents the Heli-claw from spinning in flight (Figure 2) and keeps the Heli-claw aligned with the helicopter. A continuous electrical contact swivel connects the lower end of the longline to the Heli-claw, preventing the longline from twisting.

Figure 2. The loaded Heli-claw in flight.

In forward flight, the Heli-claw is very stable, whether it is loaded or not. It remains stable at speeds up to 80 knots even while opening or closing. When the fuel and hydraulic reservoirs are full, the Heli-claw weighs about 400 kg, including the longline, swivel, and accessory hardware. The Heli-claw was designed to pick up one tonne of material. The maximum loaded weight is about 1500 kg, but helicopter performance charts and the altitude at the site will dictate the allowable loads.

The developers of the Heli-claw can provide detailed mechanical drawings and specifications upon request. It wasn't possible to put a price on the device because it was a one-off research effort and the specifications changed several times during development.

The developing engineers stated that the Heli-claw can be adapted for use on a hauler. With minor modifications, wireless remote operation is possible. It will have to be attached to the existing rigging of the hauler, whether grapple or strops, and operated remotely to pick slash from streams and then disposed of it at a safe distance from the highest flood level of the waterway (or the slash could be brought to the landing if necessary).

A simple costing calculation suggests that if using the hauler to remove slash after each corridor is logged, it would take around one hour of the hauler time (~ $1000) and in an average harvest setting of 200 m yarding distance (~ 400 m^3) and about 15 m of creek to clean, it would translate to about $65 per metre. On a production volume basis it would translate to about $2.5/$m^3$ of merchantable volume.

Using the Heli-claw on a helicopter as designed, and assuming $2500/hour (getting to the site and back additional one hour) for a helicopter, and an estimated creek slash removal rate of about 100 m/hour, would translate to about $50 per metre – comparable to using a hauler. However, the helicopter loads will be quite variable in size – slash can sometimes be dug into the ground and pulling it may result in highly variable dynamic loads which can create a safety hazard for the pilot.

In a further development Dale Ewers from Moutere Logging Ltd in Nelson has been looking at developing a slash grapple to deal with this problem. Progress on this development will be monitored.

Miniyarders

Back in the 1980's the Missoula Technology and Development Centre (MTDC) developed a small truck-mounted yarder called the Bitterroot Miniyarder to make it possible to yard light slash, thinnings, and small stems from steep slopes cost-effectively.

This small yarder was developed to operate on terrain and soils that may prevent conventional ground skidding, or where larger cable systems are inefficient and uneconomical because of the materials' small size.

The Bitterroot Miniyarder is a compact, two-drum skyline yarder that weighs 750 kg fully rigged. This Miniyarder was mounted easily in the bed of a ¾-ton pickup truck (Figure 3) or could be mounted on a trailer.

Figure 3. The compact, two-drum Bitterroot Miniyarder .

It is light enough to be transported by helicopter. It can also be put on skids and towed or self-skidded, or can be mounted on a frame with tracks to propel itself.

The Miniyarder has a 18 HP Briggs & Stratton twin cylinder, air-cooled engine and mechanically operated band type brakes. It requires a minimum crew of two and uses 240 metres of lightweight 6mm cable. This, combined with its mobility and simple set up (Figure 4), make the Bitterroot Miniyarder an easy-to-operate machine. The yarder's rugged construction and simple operation allow regular forest crews to operate and maintain it.

It can pull up to one tonne loads at line speeds of about 40 metres per minute, with a maximum line speed of 120 m/min.

Parts and materials for a fully rigged Miniyarder are estimated to cost around NZ $30,000. It could realistically be assembled and ready for about NZ $50,000 and with two men required to operate it, its estimated total daily costing would be around $700. More detailed design specifications can be obtained from the author upon request.

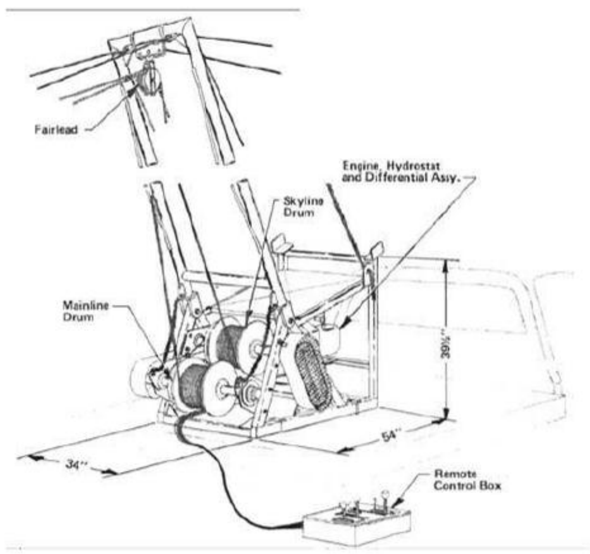

Figure 4. Schematic diagram of the Bitterroot Miniyarder.

The Miniyarder should be capable of cleaning about 100 m of stream in an 8-hour day, which would translate to about $7 per metre.

Some issues to be considered are closer access to creeks (limited rope length) and possibly the weight of some of the material left behind after a harvesting operation.

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A slightly bigger option is the Clearwater Yarder developed by the MTDC (Figure 5). The three-drum yarder weighs only about 6 tonnes fully rigged, yet can pull loads up to 1.5 tonnes at maximum line speeds of 300 m/min. It can operate uphill or downhill on steep slopes and at yarding distances of 250 metres.

Figure 5. The Clearwater miniyarder.

It is designed to be built in small shops using standard parts, easily mounted on a suitable flatbed truck or trailer, and for rapid and simple setup. It is remotely controlled for safety and minimum crew size, and has slack pulling capabilities if operated with an appropriate carriage. It is equipped with a 68 HP Ford LSG-633 P 6-cylinder engine and hydraulically operated drum type brakes.

Other options are excavator-based yarders such as the GRIZZLY 400-yarder from the Swiss manufacturer Herzog Forsttechnik presented in Tech Watch No. 8. A slightly bigger option is the Clearwater Yarder developed by the MEDC (Figure 6). This three-drum yarder weighs only about 6 tonnes fully rigged, yet can pull loads up to 1.5 tonnes at maximum line speeds of 300 m/min. It can operate uphill or downhill on steep slopes and at yarding distances of 250 metres. It too is designed to be built in small shops using standard parts, easily mounted on a suitable flatbed truck or trailer, and for rapid and simple setup. It is remotely controlled for safety and minimum crew size, and has slack pulling capabilities if operated with an appropriate carriage. It is equipped with a 68 HP Ford LSG-633 P 6-cylinder engine and hydraulically operated drum type brakes. Its cost would be expected to be a bit higher than the Bitterroot Miniyarder simply because of its size.

All of these miniyarders will be cheaper and more efficient options than using any of the bigger swing or tower yarders for slash removal from creeks.

“Walking” Excavators

A class of small wheeled excavator-type machines called “walking machines” or “spiders”, due to their unique design with stabilisers or “legs” have been available for about 40 years. There are a large number of these machines being produced, largely central European in origin. The two main manufacturers are Kaiser in Liechtenstein and Menzi Muck in Switzerland. Machines are also made in Italy by Euromach. A detailed report describing a woodlot logging operation where a Kaiser Spyder S2 bunched large farm trees on a slope for extraction by cable skidder was published by FFR in 2011 (Amishev and Evanson, 2011). Currently there are two of these machines available in New Zealand – the Kaiser Spyder S2 owned by contractor Karl Schwitzer from Cambridge, and a Menzi Muck A91 owned by Paul McCready from Porirua. Simple costing would suggest that at $1000 daily rate and 200 to 250 m of cleaned stream per day it would cost less than $5/m. This is comparable to using manual labour but an excavator would be able to remove the slash well away from the stream bed and most likely above the flood levels, unlike manual workers. There are some issues though:

- Despite their light weight (less than 10 tonnes), regional council consents would be required for machines working in streams.
- In very steep areas, access may be limited, even for these machines which can be equipped with a winch.
- In steep V-shaped creeks they may not be able to reach above flood level.

Table 1. Summary of options and costs.

Option	Costper metre	Cost per m^3
Heli-claw	50-65	2.0-2.5
Miniyarder	7-8	0.4-0.5
"Walking "excavators	5-6	0.3-0.4
Manual	5-8	0.3-0.5

In conclusion, slash cleaning from streams is an important issue for industry. Current methods can be difficult, hazardous, ineffective and expensive. Burning is an option that has been practiced before, and is certainly permitted in some regions of the country. Due to fire danger, air quality concerns and timing, burning may not be effective or even permitted. Some options were presented here, based on simple cost calculations (Table 1). An assessment trial should be conducted involving one of these "walking" excavators to investigate their suitability for removal of slash from streams and gullies on steep terrain.

References:
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Amishev, D. and Evanson, T. "Walking Machines" in Forest Operations. FFR Tech Note Vol. 3 (9), 2011, 7 pp.

OVERSEAS HARVESTING RESEARCH

Low-Investment Fully Mechanised Thinning

This research investigated a potential cost effective system for thinning small sized trees.

Thinning small sized trees is usually expensive and produces low value products. However, the potential for the thinned trees to be used as energy wood has created new opportunities. From a productivity and cost perspective, these thinning operations are often best suited to tree-length systems. Raffaele Spinelli and Carla Nati have published an article in the Croatian Journal of Forest Engineering (Vol.30(2): 89-97) titled "A Low-Investment Fully Mechanised Operation for Pure Selection Thinning of Pine Plantations". The research was carried out in *Pinus halepensis*.

The study tested a full tree system (extraction with branches and top intact) on relatively flat terrain with the following three specifications:

1. it must be able to carry out a selective thinning without opening up strip roads;
2. it must be completely mechanised with no labour on the ground; and
3. it should not have a high capital cost.

The developed system included:

1. Feller buncher – A disc-saw with accumulating arms mounted on the universal implement hitch of a 58 kW, 4-tonne tracked skid-steer loader. It reversed down every second inter row, selecting trees to fell on both sides and placing them in 3-5 tree bundles in the middle of the inter row.

2. Grapple skidder – a 44 kW farm tractor with a skidding grapple mounted on the three-point linkage. The skidder selected the bundles and dragged them to a chipper.

3. Chipper – Trailer mounted drum chipper powered by a 162 kW independent engine and its own loader. When sufficient material was available, the chipper was started up and the chips were blown directly into waiting transport trucks.

The site was thinned from 1670 to 1207 stems per hectare (463 trees removed per hectare = 28%) and the biomass yield per hectare was 27.5 oven-dry tonnes (odt). The felling and extraction was balanced at approximately 40 trees/hour, but the chipper productivity was nearly double.

The entire investment cost for the system amounted to €338,000 (including the truck and tractor to move the chipper). The feller buncher and grapple skidder cost was €98,000. With the price of chips being at €85/odt, the operation became profitable when harvesting trees of 19 cm DBH and larger. However, if the chip was increased to €100/odt, then the breakeven point is at 15 cm DBH.

Timber Transport Carbon Emissions

Sean Healy of the US Forest Service, and other researchers (see reference), addressed the question of carbon emissions from timber harvesting in an article titled “Changes in timber haulage emissions in the context of shifting forest management and infrastructure”. The article was published in the Carbon Balance and Management Journal 2009.

Their research had three main objectives:

- Develop a methodology that can be used for these types of calculations in the future.
- Determine how transport emissions can reduce the carbon sequestration value of the timber in the study area (Western Montana, USA).
- Determine if patterns of transport emissions versus sequestration have changed over the last 20 years.

In their study area, the percentage of carbon emissions from timber transported had increased as a percentage of carbon sequestrated, over the last two decades. This percentage was 0.5% in 1988 and rose to 1.7% in 2004 – a nearly fourfold increase in emissions. Reduced timber volumes were available near mills, mainly due to decreased logging on federal land. More importantly, mill closures have resulted in timber travelling further to the remaining mills. The average road distance increased from 46.3 km (28.8 miles) in 1988, to 82.9 km (51.5 miles) in 1998, to 214 km (133 miles) in 2004.

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http://crojfe.sumfak.hr

TECHNOLOGY OUTSIDE FORESTRY

New Omni-Crawler can move in all directions

When the need to move super-heavy objects arises, short, squat crawlers are usually deployed. Unfortunately, their heavy lifting ability comes at the sacrifice of mobility (no sideways motion), so manoeuvring objects into place can be a difficult and lengthy process.

Recently, researchers from Japan's Osaka University (OU) designed an omni-directional wheel known as the Omni-Ball (Figure 6), to travel in virtually any direction with minimal energy loss.

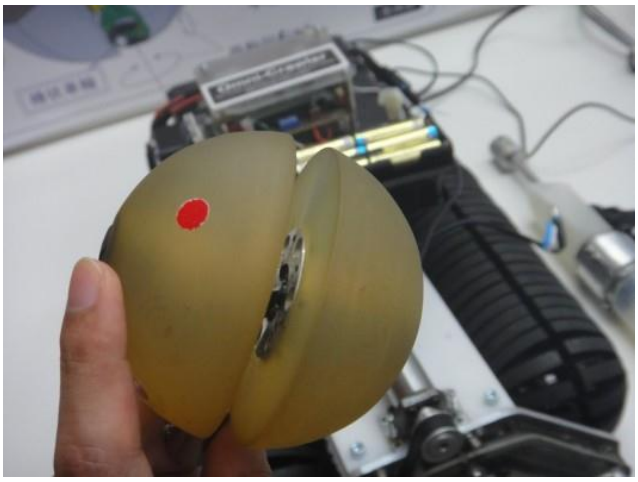

Figure 6. The Omni-Ball – two-piece ball-shaped wheel.

The Omni-Ball consists of two matching hemispherical "wheels" connected to one another on either side of a short axle. The separate halves can rotate independently of one another, or in tandem as a complete sphere.

From this innovative development they also developed an innovative battery-powered, remotely controlled prototype crawler that they have dubbed the Omni-Crawler (Figure 7). The concept is far from new since the quest for omni-directional robots/vehicles has existed for some time. This device is however unique in that it utilises two cylindrical crawlers which incorporates properties from the team's unusual, two-piece Omni-Ball wheels.

"By rotating the axle dynamically using a motor, we can effectively combine the direction of the driving force and the direction in which the structure moves as a caster." A moving object with at least three of these wheels can generate a driving force in all directions," explained OU's Kenjiro Tadukama.

"With a conventional crawler, if you position it to enter a narrow space, the crawler has to turn round repeatedly, but this crawler can move sideways as well, so it's easy to fine-tune its movements," said Tadukama. "Ordinarily, there's a lot of energy loss due to turning, but this crawler can be positioned immediately by moving to the side just a little. So we think this crawler can greatly minimise energy loss as well."

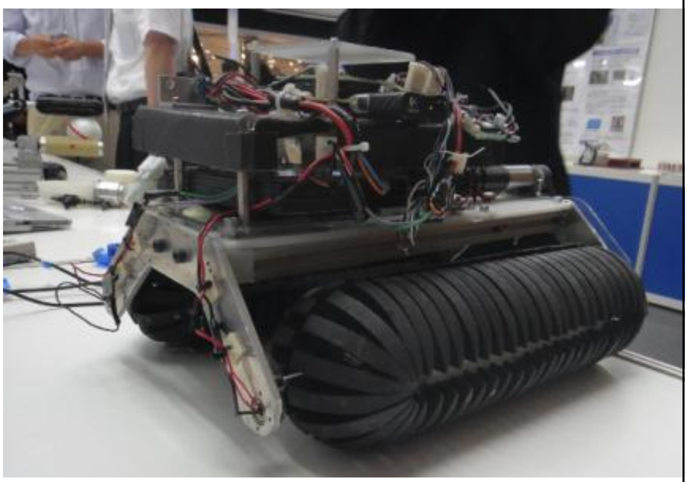

Figure 7. The Omni-Crawler developed by Japanese researchers.

The OU researchers also showcased a number of other devices, including a "planetary exploration robot," that are based on the Omni-Ball/Crawler technology. The potential applications for this technology seem endless, so we may see many things rolling along a lot more smoothly in the not-too-distant future.

Such machines would be especially beneficial for forestry operations where obstacles in the form of stumps, logs, rocks, etc are common. They would enhance productivity and safety in such conditions.

References:

http://www.gizmag.com/omni-crawler-moves-in-all-directions/20386/